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JARED POTTER KIRTLAND,

PHYSICIAN, TEACHER, HORTICULTURIST, AND EMINENT NATURALIST.*

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The adolescent in science like the adolescent in youth is more likely to be impressed by good example than by much exhortation. The choice of my subject is in part influenced by the desire to bring to the attention of the younger members of the Ohio Academy of Science a scientist whom they may well emulate.

To the more mature as well as to the younger, it is both of interest and advantageous to be reminded of those who have preceded us and to learn something of their careers. It is especially fitting that the Ohio Academy of Science should acknowledge its indebtedness to the pioneers of science in Ohio.

Therefore I have chosen as my topic to sketch the life and career of Jared Potter Kirtland, who so largely influenced the development of interest in natural science in Ohio.

ANCESTRY.

We have long heard much discussion as to the relative importance of inheritance and environment, not only in biological doctrine, but as well in human society. However, when an individual is the happy recipient of both favorable ancestry and of advantageous surroundings and opportunity there is a summation of the influence of inheritance and environment that promises important results.

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Nathaniel Kyrtland (1616-1686) came from Tickford, Buckinghamshire, England to Massachusetts Bay in 1635 and settled at Lynn. His son, Lieutenant John Kirtland (1659-1716), migrated to the lower Connecticut Valley and settled at Saybrook, Conn. Here he and his children played important parts in colonial history. He himself became commander of the fort at Saybrook Point and led his fellow colonists in several battles with the Indians in the closing years of the seventeenth century. One of his descendants, John Thornton Kirkland, (1770-1840),—for the two names are but variants—was President of Harvard College from 1810-1828. Rev. Samuel Kirkland, the renowned missionary to the Indians, was also a descendant. Early in the eighteenth century several of the family moved up the river to Wallingford, Connecticut. Here in 1755 was born Turhand Kirtland, the father of the subject of this sketch.

When in 1796 the Connecticut Land Company bought three million acres in that area of north-eastern Ohio known as the Connecticut Western Reserve, its officers sought a man to represent them as resident general agent in this frontier area. Their choice in 1797 fell upon Turhand Kirtland, a veteran of the Revolutionary War then forty-two years of age, and it proved a wise choice, for during the closing years of the eighteenth century and the early decades of the nineteenth century this man showed himself brave, resourceful, and just. He had both breadth of vision and integrity and to him largely is due the fact of unbroken friendliness between settlers and Indians in that region. He was an associate judge, a member of the state senate and a trustee of Western Reserve College.

In testimony of his attitude toward the Indians one incident will suffice. Soon after Turhand Kirtland came to the Western Reserve in 1797, a white man killed an Indian in a drunken brawl. Kirtland at once had the white man arrested. There were no established courts in that part of the state but he sent to Marietta and induced two duly appointed judges to journey two hundred miles to try the white man. Primarily on the testimony of Indians who were eye witnesses of the killing, self defense was proven and the man acquitted. The Indians were entirely satisfied. This incident so firmly established the reputation of Turhand Kirtland for fair dealing that he became the accepted arbitrator when the Indians had any disagreement with the white settlers.

Not only on the paternal side, but also on the maternal side, Jared Potter Kirtland was fortunate in his ancestry. His mother, Mary Potter, counted in her forbears, both direct and collateral, a line of able and influential persons. Her father Dr. Jared Potter (1742-1810) was reputed to be the leading and most learned physician in the Connecticut of his day. Graduated at Yale in 1760, he studied medicine with the most scholarly physician in that colony and early acquired an interest not only in medicine but in many other lines of knowledge including natural history. He continued throughout his life to be a student and a leader in his profession founding the first State Medical Society of Connecticut. He was also a leader in his community and was continuously a member of the legislature for the last eighteen years of his life.

EARLY LIFE AND EDUCATION.

Jared Potter Kirtland, the eldest son of Turhand Kirtland and Mary Potter his wife, was born at Wallingford, Connecticut, November 10, 1793. He was ten years of age when his father moved the family to Ohio, but the lad was not taken to the frontier. Instead he was put into the home of his grandfather, Dr. Jared Potter, under whose guidance for seven years he was carefully educated, and in his boyhood days, learned to like to study. As a boy he took prizes in Mathematics, in Greek, and in Latin. He acquired that taste for the classics that resulted in his reading the classic authors in the original as a recreation up until the closing years of his life.

It was not alone in formal school study that he was trained. His grandfather inculcated in the boy a love of natural history and taught him accurate observation and the habit of recording his observations, a habit which was maintained throughout his life and in large measure accounts for the wealth of original observations shown in all his writing. Dr. Potter had an extensive orchard which included mulberry trees where the attempt was being made to produce silk. At ten years of age the lad was carrying on experiments in improving fruit trees by budding and grafting. At eleven he was making experiments with bees and studying their enemies. At twelve he made his first scientific discovery of importance when he showed, by breeding experiments, that the silk worm moth can reproduce parthenogenetically, something that had never

before been recorded, and preceding by nearly fifty years Siebold's work on parthenogenesis.

At fifteen years of age in 1808 he made a summer trip to Ohio. At seventeen years of age Jared Potter Kirtland came to Ohio to his father's residence at Poland, Ohio. Here he taught school, but his chief interest was in exploring the adjacent country, observing the flora and fauna, and working in his father's orchards.

PROFESSIONAL EDUCATION.

Before a year had elapsed Dr. Jared Potter died (July 1810), making a considerable bequest to his grandson and giving him his rather extensive library. Thereupon young Kirtland returned to Wallingford, Conn. and began the study of medicine under the preceptorship of two local physicians. During a part of this time he was studying at Yale College as a private pupil of Professor Eli Ives in botany and of the elder Silliman in mineralogy and geology, both of these men having been friends of his grandfather. The fortunate circumstances that brought Kirtland in his youth into intimate contact, first with Jared Potter, and later with Ives and Silliman had great influence upon his scientific career for all three were men of outstanding ability and scientific zeal.

With the bequest of his grandfather, Kirtland, yet under twenty years of age was able to plan his career without financial restriction. His purpose was to go to the University of Edinburgh to study medicine, but before he was ready to depart the war of 1812 came on and that procedure had to be abandoned.

It happened that just at that time Dr. Nathan Smith, eminent as a medical teacher, came from Dartmouth to found the Yale Medical Institution and in 1812 at the age of nineteen Kirtland became the first matriculant in that new medical school. After one session, he did the common thing of migrating to another school and went to the University of Pennsylvania where he spent the session of 1813-14. Here he came into close relations to Barton the botanist under whom he wrote a thesis.

In 1814 Kirtland was in bad health and he spent some months in Wallingford and in the autumn of 1814 returned to the Yale Medical Institution where he graduated in medicine in March 1815 at the age of twenty-one.

His education had brought him into contact with the leading medical school of the country and with two of the best colleges, but also it had given him rather intimate relations with three of the leading scientists of the day namely Barton, Ives, and the elder Silliman and with Dr. Nathan Smith, leading medical teacher. This, in addition to his early training under his grandfather Dr. Jared Potter and his own taste for study, gave him a background rarely accorded in that day. His environment and opportunities had been most favorable toward developing his innate ability, a heritage from an able ancestry.

MEDICAL CAREER.

On graduating in medicine Dr. Kirtland married and returned to Wallingford, Conn., his native town, to practice medicine. His popularity is attested by the fact that within about a year, at the age of twenty-three, he was elected judge of probate. He practiced medicine at this location for five years and then moved to Durham, Conn. Here in 1823 his wife and second child died. The result was a great despondency.

He now, at the age of thirty, resolved to abandon medical practice and moved to Poland, Ohio, planning to follow his father, then seventy years of age, in the conduct of the extensive mercantile business he had there developed. But a pioneer community with no other well-trained physician in it would not permit Dr. Kirtland to remain inactive medically. He soon was deep in an extensive medical practice, and had abandoned his idea of store-keeping, but not of avocations. In 1825 he again married. His country riding gave him opportunity to study the flora and fauna, and soon he focused attention on the fresh water bivalve mollusca of the Mahoning river, which led to two important contributions to zoological knowledge. He discovered in 1829 that the individuals of these mollusca are of separate sexes, instead of hermaphroditic as always had been taught before that time. This discovery was first published in 1834 in the American Journal of Science. In the same journal in 1840 he published the discovery of the byssus, the larval organ of attachment in these animals.

These two discoveries made his name known in Europe and brought him the friendship of prominent American zoologists, not least of whom was Louis Agassiz.

Natural history was not his only avocation. He continued the interest of his boyhood in improving fruits and developed on his farm at Poland, Ohio, excellent orchards and small fruits, and as early as 1831 began writing for horticultural journals.

He became well known and popular in his community and in 1827 was elected to the legislature and twice reelected. In the legislature he was at once put on several important committees and on his first reelection he was made chairman of the Committee on the Penitentiary. In that session he carried through a reform in the management of the Ohio penitentiary whereby useful labor replaced solitary confinement, a change so well accepted that he was called the "Father of the Penitentiary." He also had important influence in the legislature toward the construction of the Ohio and Pennsylvania canal.

With all these activities his medical practice extended and, in the middle 1830's he came to have the reputation of being the best and most learned physician in northern Ohio. He was active in the State Medical Convention, being its president at its third session held in Cleveland in 1839, where, as his presidential address, he presented an extensive review of the climate and meteorology of Ohio since its first settlement and the relation of these conditions to the diseases of that period. Later, in 1849 he was made president of the State Medical Association.

CONNECTION WITH OHIO GEOLOGICAL SURVEY.

Beginning in South Carolina in 1823 there was a wave of organization of state geological surveys. By 1836 it included ten of the eastern and southern states and also a United States Survey. In 1836-37 the first Ohio Geological Survey was organized. In this survey Dr. Kirtland was put in charge of Zoology. In the membership of the survey there were three other physicians, namely, Drs. S. P. Hildreth, John Locke, and John L. Riddell. Dr. Kirtland worked with great energy. Financial support from the legislature was scanty but Dr. Kirtland not only suspended his own pay in order that the geological features of the survey might proceed but also he personally paid the stipends of his assistants so that the work in zoology might go on. Only when the project was entirely abandoned did he desist. Out of this work came his list of

Ohio Vertebrates containing 585 entries and his pioneer work on the Fishes of Ohio, which, the state refusing to print, was published in the Journal of the Boston Society of Natural History in 1839-1846. In 1840 he published a description of the kidney worm parasitic in swine, the first record of its occurence in America.

TEACHING CAREER.

In 1837 there was a vacancy in the Professorship of the Theory and Practice of Medicine on the faculty of the Medical College of Ohio at Cincinnati, then the only regular medical school west of the Alleghenies and north of the Ohio river. To this vacancy Dr. Kirtland, a country practitioner, was called. Here at forty-four years of age he began his career in medical teaching which continued for nearly thirty years, a career marked by the reputation of breadth, clarity, scholarliness, and practicability, and withal outstanding in excellence.

In 1837, the same year that he began teaching medicine in Cincinnati, Dr. Kirtland left Poland, Ohio and bought a farm at Rockport, five miles west of the center of Cleveland, where he resided for forty years until his death in 1877. Here he continued extensive experimentation in various branches of horticulture. He spent the teaching term from November to March at Cincinnati and the balance of the year at Rockport. This continued for three years. Then he resigned at Cincinnati and in 1840 joined the faculty of the Willoughby Medical School. This change permitted him to live the year round on his Rockport farm where his experimental work was broadening.

In 1838 he had as a colleague on the medical faculty in Cincinnati, Dr. John Delamater, a man at that time reputed to be the best medical teacher in the United States, and who in his teaching career held professorships in nine different medical schools. Dr. John Delamater was the leading figure in the Willoughby Medical School and it was through his influence that Dr. Kirtland joined that faculty in 1840. There he first met Dr. John Lang Cassels, a Scotchman educated in the University of Glasgow and at a New York medical school, who later did important work in Botany and Geology.

In 1843 Dr. Kirtland with Delamater, Cassels, and Dr. Horace A. Ackley resigned from the Willoughby Medical School and founded the Cleveland Medical School (now the

School of Medicine of Western Reserve University) in which Dr. Kirtland continued as Professor of Medicine until he reached the age of seventy-one, in 1864.

CONNECTION WITH SCIENTIFIC SOCIETIES.

On that faculty was a group of seven scholarly men said to constitute one of the best balanced medical faculties in the country, and also there were other able men in the community who were interested in natural science. These Dr. Kirtland, in 1845, organized into the Cleveland Academy of Natural Sciences. Of it Dr. Kirtland was president for twenty-five years until he was compelled to withdraw by reason of the feebleness of age. In his honor its name was later changed to the Kirtland Society of Natural History.

At its monthly meetings were presented able papers, not only by members but by visiting scientists. The range of subjects was wide and included many fields of Zoology, Botany, Geology, Paleontology, Mineralogy, and Meteorology. The Academy at once started a museum to which was contributed much valuable material. The present Cleveland Museum of Natural History is its direct lineal successor.

Dr. Kirtland had been active in a scientific society at Cincinnati during the three years of teaching there. In 1839 he became a member of the Boston Society of Natural History. He was one of the founders of the American Society of Geology and Natural History in 1840 and also of its successor, the American Association for the Advancement of Science, in 1845. He was a member of the Philadelphia Academy of Natural Science, and of the American Society of Conchology and probably of the natural history societies in New York and Chicago. In 1864 he became a member of the American Academy of Science, being elected to fill the vacancy caused by the death of Benjamin Silliman, the younger. In 1875 at eighty-two years of age he was elected a member of the American Philosophical Society. To all of these societies he contributed papers.

In addition to these societies of Natural Science, he held membership in a group of societies connected with agriculture and horticulture. In many of them he held offices, of several he became president and to all of them he contributed papers.

PUBLIC SERVICE.

Dr. Kirtland was always helpful in public service. Mention has been made of his service as probate judge and his career in the legislature. When the civil war came on he was sixty-eight years old. The government would not send him into the field but he served through the war as examining surgeon at Cleveland and turned over all his pay to be used in aiding soldier's families.

When Cleveland came to seek to supplant its wells and springs with lake water Dr. Kirtland was the most active one of a committee of three that planned and put into operation the first water supply system of Cleveland. Before the civil war he and two others (Drs. Nathan Strange Townshend and John Strong Newberry) established winter courses in agriculture given first at Oberlin and later at Cleveland. He was one of the small committee of the Ohio Agricultural Society that for many years sought the establishment of an agricultural college, a plan finally successful when, in 1874, instruction began in what has now become Ohio State University.

HIS GENERAL REPUTATION.

One would expect with such diversity and versatility there would have been superficiality but no evidence of it appears. On the contrary he appears to have excelled in every vocation or avocation to which he put his hand.

First of all there is plenty of evidence that he was held in high regard by profession and laity, through more than fifty years, as a very good general practitioner of medicine. He was considered both by colleagues and students as an excellent medical teacher. He held professorships of medicine in three different medical schools in Ohio covering a period of twenty-seven years of active teaching.

In horticulture he had an international reputation. This was not only as regards fruits, but extended to ornamental trees and also to floriculture. He did some work in animal breeding. He was elected to honorary membership in the most exclusive horticultural societies. He developed many new varieties of flowers and fruits. His results in the cultivation of cherries included the development of over forty new varieties and his success was so preeminent that he was referred to as the "Cherry King." Also he improved the culture of apples, pears,

grapes, raspberries, and strawberries. In other fields of agriculture he was considered an authority and was frequently quoted, in other parts of the country, on such diverse subjects as bee culture, windmills, and rural architecture.

HIS SCIENTIFIC CONTRIBUTIONS.

Dr. Kirtland was a prolific writer upon a great variety of subjects. In an attempt to compile his bibliography I have so far collected over two hundred titles of signed papers, beside many more, found in journals to which he was accustomed to contribute, that bear imprint of his style of writing but are not signed. Many of these are initialed "K" but may have been written by his brother Dr. Billius Kirtland, who was also a capable naturalist and horticulturist. Dr. Jared Kirtland's papers fall into four groups: medical, zoological, horticultural, and miscellaneous.

The medical papers are not numerous. I have but ten but these bear evidence of careful observation, clear deduction, and progressive thinking as to etiology, diagnosis, and therapeutics. It is of interest to note that in 1851 he wrote a paper in which he said he was convinced that typhoid fever comes from the drinking water. This was thirty years before we knew of bacteria.

Of the zoological papers I have been unable to locate his original description of parthenogenesis in the silk worm moth. In later papers he makes reference as to the facts and date of his experiments and discovery but does not say when it was published nor does he definitely say it was published. The first important papers were on the bisexuality of fresh water bivalve molluscs and the description of the byssus. These were published in the American Journal of Science in 1834 and 1840. The list of 585 Ohio vertebrates was published in the second report of the Ohio Geological Survey in 1838 and the series of papers on the Fishes of Ohio were published in the Journal of the Boston Society of Natural History from 1839-1846. Some seventy other zoological papers relating to parasitic worms, mollusca, lepidoptera, hymenoptera, fishes, reptiles, birds, and mammals appear in a variety of journals and society proceedings.

His zoological interests appear to have been centered on fishes and birds. He was not satisfied with merely possessing preserved specimens, but was interested in their food, their

habitat, habits, and range and especially in the occurence of previously unrecorded species. It will be recalled that a warbler was named after him. It is probably less well known that a bivalve mollusc, a snake and a fossil were also given his name by their discoverers.

INFLUENCE IN POPULARIZING NATURAL SCIENCE.

Great as was his influence upon professional men and those engaged in scientific pursuits, yet perhaps greater was his influence along scientific lines upon the laity. To appreciate this it is necessary to recall that before the Civil War this region was predominantly one of agriculture and that in rural communities reading was a much more popular art than it is today.

In 1850 Dr. Kirtland became editor of the Family Visitor, a popular weekly journal published first at Cleveland and later at Hudson, Ohio. This was less a publication of news events than a compilation of extracts from many sources. These extracts concerned social, literary, religious, and political affairs but there was a large number of articles on natural science including chemistry, physics, astronomy, meteorology, geology, zoology, and botany. Many of these were original articles. Some of these were by J. Lang Cassels and by Samuel St. John and many others were signed by Dr. Kirtland. Here he republished his work on the Fishes of Ohio and extended it. In his three years editorial connection with this periodical he clearly aimed to popularize natural science, and soon his readers began to send in inquiries and observations on fauna and flora and meteorology.

Dr. Kirtland occasionally contributed articles to the Ohio Cultivator founded in 1845. Its editor was Dr. Jehu Brainard another physician naturalist, an adherent of homeopathy, whose interest was more toward geology.

In 1851 was founded at Cleveland the Ohio Farmer. To this Dr. Kirtland became a leading contributor. His articles were given the most prominent position and usually accompanying editorial comment. After reading more than fifty of them I reach the conclusion that he wrote accurately and with a style that gives immediate interest. He tells of his own experiments, he quotes the experiments of others, and writes critically, constantly citing his own observations. All this is in excellent English with a style entirely lacking pedantry.

The Ohio Farmer had a wide circulation from the start and thus Dr. Kirtland had a large audience in those days, until his name was known at nearly every farmer's fireside in northern Ohio. Thus Dr. Kirtland was able to exert a wide influence in natural science. His subjects are varied and range from the description of some new animal form to the physics of windmill pumping. Horticultural subjects were numerous but also floriculture received much attention. Much over a hundred papers on horticultural and floricultural topics show a wide variety. They include papers on small fruits, insect pests, soil condition, manures, ornamental trees, apiculture, and many other things of interest to the farmer.

In a group of about twenty-five miscellaneous papers he discusses such subjects as garden and farm implements, the influence of amusements upon the elevation of taste, Sabbath observation, the peculairities of climate and its effects, methods and value of meteorological observations, public hygiene, animal instinct, the application of science to farming, landscape gardening, and rural architecture. In a paper on the latter subject in 1855 he advocated the use of cement as a building material for houses and barns, citing its advantages over both lumber and stone.

Dr. Kirtland was no mere theoretical writer, but his practice was as successful as his writing. At the county fairs and horticultural exhibitions his name appears again and again among the prize winners except in those instances where he was a member of the board of judges, which often happened, thus indicating that he had the confidence of the public.

Comparable to Dr. Kirtland's efforts and success in popularizing natural science with the laity was the stimulus he gave to interest in natural science through his influence upon his colleagues and his students.

He was the acknowledged leader of that group of professional men who became lovers of natural history and who made up the membership of the Cleveland Academy of Natural Sciences, among whom were such men as Brainard, Cassels, Garlick, Kirkpatrick, St. John, Winslow, and Whittlesy all of whom acknowledged the stimulus that Dr. Kirtland gave them. Dr. Kirtland was a frequent associate of Dr. Townshend to whom chiefly Ohio State University owes its origin. Dr. Townshend, also a physician and an ardent horticulturist, lived only a few miles away from Dr. Kirtland's residence.

Many of the students in the three medical schools where Dr. Kirtland taught caught from him the love of Natural History. All told he taught over three thousand medical students. He early established a museum in Cleveland Medical College and here he met the students to instruct them not only in medicine but in natural history. He lectured to them on birds, and bees, and insects. These men went far and wide to practice medicine and carried some liking for natural science and knowledge of it that they owed to Dr. Kirtland. No measure can be made of the influence of these men in natural science in the localities where they practiced but there is evidence that it was considerable. Some of these students became prominent in science. Of such Dr. John Strong Newberry, eminent geologist, is an example.

PERSONALITY.

One cannot discuss Dr. Kirtland without some reference to his personality. He was of a commanding physique and with a head that indicated intellectuality and carried dignity. He had a kindly countenance that inspired confidence. He was not only the loved physician but also the idol of the community in which he lived. He was familiarly known as the "Sage of Rockport," a testimony to the respect for his knowledge, but also he had an attractive personality that drew all to him.

One incident will illustrate this. In his study of birds he could find no one to do the taxidermy and so he trained himself in this art and then trained others to follow it. His own preparations were excellent enough so that some of them were accepted in leading European museums. Some of his pupils became professionally connected with various museums, but the incident that shows his personal charm is that when he was past seventy years of age a group of society young ladies of Cleveland weekly drove five miles to his residence to take lessons from him in preparing skins and mounting birds. This seems to bear testimony of personal charm when a man of seventy attracted society maidens to indulge in the somewhat messy work of taxidermy.

His simplicity and lack of egotism was proverbial. One anecdote will suffice to show this as well as his sense of humor. On an occasion a prominent eastern horticulturist who had not met Dr. Kirtland came to Cleveland to consult him. Driving

out to Dr. Kirtland's home he stopped his horse and seeing an old gentleman in torn straw hat and overalls hoeing among the flower beds he accosted him with the question "Is this the home of Professor Kirtland." The reply was "It is." "Is Professor Kirtland at home?" The man with the hoe replied, "He is." Then the visitor said, "Well my man come and hold my horse." Obediently the old gentleman advanced and held the stranger's horse while the visitor, preening himself, advanced to the door of the residence which was opened by Dr. Kirtland's daughter. He asked "Where can I find the renowned Professor Kirtland?" The daughter replied "He's out there in the street holding some man's horse."

Dr. Kirtland although not wealthy happily had sufficient resources so that he was able to be benevolent. This extended to both public and private contributions. The incidents in reference to the pay of the assistants on the geological survey and the contributions to soldier's families have been mentioned. Another more extensive is equally pertinent. When in 1845 the erection of a building for the Cleveland Medical College was halted for lack of funds, Dr. Kirtland, though but one of seven organizers of the school, on his personal note borrowed $3000 to complete the $8000 building, a note that was not paid until nearly twenty years later. His private benevolences were also numerous but unheralded.

LATER YEARS OF LIFE.

In 1864 at the age of seventy-one Dr. Kirtland resigned from his teaching duties, and also largely retired from medical practice, to devote himself to natural history and horticulture. A few years later he made a natural history trip of several weeks to Florida, and even at eighty years of age was active but soon his physical vigor began to abate and for the last few months of his life he was physically feeble but still alert mentally and intellectually, approaching the end with dignified confidence. He died quietly and peacefully at Rockport, Ohio, December 10, 1877, having by one month passed his eighty-fourth birthday. The community as a whole watched the closing days of his life and mourned his going but rejoiced in his career, and throughout the country in many a scientific group formal acknowledgment was made of his greatness.

CONCLUSION.

At a distance of a half a century we recognize here a truly great career. Here was a man who was physician, teacher, judge, legislator, editor, writer, horticulturist, and a real scientist. For us who falteringly follow in the footsteps of such great men it is of value to attempt to make an analysis and separate out some of the elements which made this career so outstanding.

First of all was the heritage of the idea of the nobility of accomplishment and service coupled with unselfishness. This came from a line of pioneers, who, by reason of small numbers, were forced to cooperate and could not succeed if they were selfish. The man who makes science his vocation rarely succeeds if his chief aim is personal aggrandizment.

Next was the forcefulness of early education. It seems that if any one individual deserves especial credit for Dr. Kirtland's career that person is his grandfather Dr. Jared Potter who taught this lad to study, to work hard, to record his observations and encouraged him in experimentation and independent thinking.

A third factor was the opportunity for intimate contact with a few great scientists of his day. These he admired and emulated and these contacts guided the capabilities started in the training of boyhood. Today the opportunity for contact with trained scientific minds is so common-place as to be little appreciated and often neglected.

Next comes the fact of Dr. Kirtland's catholicity of interest. He was no narrow specialist shut up in the confines of the study of a single phenomenon or of a single group of biological forms. His breadth of information, originally secured, gave opportunity for comparison which developed judgment, wisdom, and sagacity.

Then comes the habit of orderliness begun in early youth in making records and continued as evidenced by his writing. If one reads any of Dr. Kirtland's papers he is immediately impressed with the logic of presentation. The major premises have their proper position. The elaboration is clearly that and not a part of the premise and in brief and cogent phrases he proceeds to a conclusion which the reader is forced to accept. His style is terse and correspondingly convincing. In science neither the

disorderly mind, nor the disorderly laboratory leads to successful fruition.

Finally the outstanding element in this career is industry, orderly industry, the capability of working constantly and assiduously toward definite goals. At his death his most intimate scientific friend, Dr. Theodatus Garlick, an associate of forty years said of him "His eminent success in the field of science is attributable to his untiring industry and his inextinguishable thirst for knowledge."

ENVOY.

The Ohio Academy of Science has a noble heritage in the careers of Ohio's pioneer naturalists. The lives of Hildreth, Kirtland, and Sullivant, to mention but three, beckon us to fruitful tasks. Today's opportunities for progress are great, far greater, than these pioneers could imagine in their fondest hopes. It remains for us, and those that follow us, to develop those three qualities which characterized the personal career of Jared Potter Kirtland, namely catholicity of interest, orderliness, and personal industry.

A REVISED LIST OF THE FISHES OF OHIO.*

RAYMOND C. OSBURN, EDWARD L. WICKLIFF
AND MILTON B. TRAUTMAN.

Nearly thirty years have elapsed since a list of Ohio fishes was issued. (The Fishes of Ohio, Osburn, Special Paper No. 4, Ohio Academy of Science, June 1901). In this report 134 native and 3 introduced species were listed from actual records of fishes taken within the limits of the state.

For a number of years after this time very little work was done on the fishes, but in 1920 systematic collecting was again undertaken by the senior author, assisted by Mr. Wickliff and others in a survey of lakes and streams for the State Division of Fish and Game. Since that time some collecting has been done every summer in connection with biological studies of the waters of the state. This work, initiated and supervised by Osburn, has been carried on chiefly by Wickliff and Trautman, though a number of others have contributed to a lesser extent. The State Division of Fish and Game (now the Division of Conservation) has financed the work, with the exception of that carried on in Lake Erie every summer by the Franz Theodore Stone Biological Laboratory of the Ohio State University.

The list now numbers, as presented here, 144 native and 4 introduced species and 9 of these are represented within the limits of the state by additional subspecies, making a total list of 157 more or less distinct kinds of fishes in Ohio. Several names have been dropped from Osburn's list for the following reasons: *Ameiurus vulgaris* Thompson is an occasional long-jawed variant of *A. melas* and *A. nebulosus; Carpiodes thompsoni* Agassiz is synonymous with *C. velifer; Opsopoeodus megalops* Forbes is synonymous with *O. emiliæ; Eupomotis euryorus* McKay is a hybrid between *E. gibbosus* and *Apomotis cyanellus*, and the introduced tench (*Tinca*) has disappeared from our waters.

*Contribution No. 102 from the Department of Zoology and Entolomology, the Ohio State University.

The increase in the list is accounted for in two ways: First, more extensive collecting has added *Petromyzon marinus*, *Clinostomus vandoisulus*, *Notropis anogenus*, *Notropis dorsalis*, *Phenacobius mirabilis*, *Schilbeodes nocturnus*, *S. furiosus*, *Microperca punctulata*, and *Cottus ricei*. Second, more careful taxonomic study, especially by Dr. C. L. Hubbs of the University of Michigan Museum, has resulted in the separation of former species into two or more. Thus a new black bass, *Micropterus pseudaplites* has been separated from the Smallmouth; the river chub (*Hybopsis kentuckiensis*) has been split into three species, two of which occur in the state; the suckers of the genus *Moxostoma* have been restudied and we now have six species instead of three, etc.

The nomenclature has undergone much revision during the past few years and many of the names now in use are recognizable only to the taxonomist. It is hardly possible that such a tangled synonomy is even yet straightened out. In the following list the authors have followed closely the work of Dr. Hubbs who has checked many of our determinations of the species. Where changes have been made in the list here presented, those of Osburn's "Fishes of Ohio" appear in parenthesis.

Except for additions to the list no occurrence records are noted, for the reason that it is proposed to issue a complete report in which will be brought together our extensive data on distribution, ecology, food, breeding and other phases of ichthyological investigation.

List of the 159 Species and Subspecies Known to Occur in Ohio.

Family Petromyzonidæ. Lampreys.

Petromyzon marinus L. Lake Erie, near West Sister Island, Nov. 14, 1927, collected by W. M. Tidd. This lamprey has been reported for Lake Erie, but not in Ohio waters.
Ichthyomyzon concolor (Kirtland).
Lampetra lamotteni (LeSueur). (*L. wilderi* Gage).

Family Acipenseridæ. Sturgeons.

Acipenser fulvescens (Rafinesque). (*A. rubicundus* LeSueur).
Scaphirhynchus platorhynchus (Rafinesque).

Family Polyodontidæ. Paddlefishes.

Polyodon spathula (Walbaum).

Family Lepisosteidæ. Gar pikes.

Lepisosteus osseus (L)
Lepisosteus platostomus (Rafinesque).
Lepisosteus tristoechus Bloch and Schneider.

Family Amiidæ. Bowfins.

Amia calva L.

Family Hiodontidæ. Mooneyes.

Hiodon tergisus LeSueur.
Amphiodon (Hiodon) alosoides Rafinesque.

Family Clupeidæ. Herrings.

Pomolobus chrysochloris Rafinesque.

Family Dorosomidæ. Gizzard shads.

Dorosoma cepedianum (LeSueur).

Family Salmonidæ. Salmons and Trouts.

Salmo fario L. Brown Trout. Introduced and established in Castalia Creek.

Salmo irideus Gibbons. Rainbow trout. Introduced into Castalia Creek, Lake Erie drainage and head waters of Mad River, Ohio drainage. Adults, probably escaped, have been taken at a number of places in the west end of Lake Erie and in the Huron River near the lake.

Cristivomer namaycush (Walbaum).
Salvelinus fontinalis fontinalis (Mitchill).

Family Coregonidæ. Whitefishes.

Coregonus clupeaformis (Mitchill).
Leucichthys artedi artedi (LeSueur). (*Argyrosomus artedi*).
Leuchichthys artedi albus (LeSueur). (*Argyrosomus tullibee* Richardson).

Family Catastomidæ. Suckers.

Megastomatobus (Ictiobus) cyprinella (Cuvier and Valenciennes).
Ictiobus niger (Rafinesque). (*I. urus* Agassiz).
Ictiobus bubalus (Rafinesque).
Carpiodes carpio (Rafinesque).
Carpiodes velifer (Rafinesque). (*C. difformis* Cope).
Carpiodes cyprinus (LeSueur). (*C. velifer* Rafinesque and *C. thompsoni* Agassiz).
Cycleptus elongatus (LeSueur).
Catostomus commersonnii commersonnii (Lacepede).

Catostomus catostomus (Forster). Jordan's Ohio Report states that this fish is "quite abundant in Lake Erie," but we have not seen it nor have other collectors noted its presence. Was the record an error or has the fish disappeared from Lake Erie?

Hypentelium (Catostomus) nigricans (LeSueur).
Erimyzon sucetta kennerlii (Girard). (*E. sucetta oblongus* Mitchill, part). The typical sweet sucker of the lakes.
Erimyzon oblongus claviformis (Girard). (*E. sucetta oblongus*, part.) The common stream form.
Minytrema melanops (Rafinesque).
Moxostoma rubreques Hubbs. Represented in our collections by one specimen from the Ohio River drainage, a paratype deposited in the Museum of the University of Michigan.
Moxostoma erythrurum (Rafinesque). (*M. aureolum* LeSueur, part). The commonest of the "redhorse" suckers, in most of the creeks and rivers of both drainages and occasionally in lakes.
Moxostoma aureolum (LeSueur). (*M. breviceps* Cope). The common short-headed sucker of Lake Erie.
Moxostoma breviceps (Cope). (*M. aureolum* part. Not the *M. breviceps* of Osburn's list). A short-headed sucker of the Ohio River drainage only.
Moxostoma duquesnii (LeSueur). (*M. aureolum*, part. Not the *Placopharynx duquesnii* of Osburn's list). Well distributed over the state but not commonly taken.
Moxostoma anisurum (Rafinesque).
Placopharynx carinatus Cope. (*P. duquesnii* LeSueur).
Lagochila lacera Jordan and Brayton.

Family Cyprinidæ. Minnows.

Cyprinus carpio L. Carp. Introduced everywhere.
Carassius auratus (L.). Goldfish. Introduced and very abundant in Lake Erie, inland lakes and larger streams.
Nocomis biguttatus (Kirtland). (*Hybobsis kentuckiensis* Raf., part). Especially in Northern Ohio on weedy ripples.
Nocomis micropogon (Cope). (*Hybopsis kentuckiensis*, Raf., part). All over the state, but does not frequent weedy places.
Erimystax (Hybopsis) dissimilis (Kirtland).
Extrarius (Hybopsis) hyostomus (Gilbert).
Hybopsis storerianus (Kirtland).
Hybopsis amblops (Rafinesque).
Rhinichthys atronasus meleagris Agassiz (*R. atronasus* Mitchill, part).
Rhinichthys atronasus obtusus Agassiz. (*R. atronasus* Mitchill, part).
Rhinichthys cataractæ (Cuvier and Valenciennes).
Semotilus atromaculatus atromaculatus (Mitchill).
Clinostomus vandoisulus (Cuvier and Valenciennes). Churn Creek, Adams County, April 20, 1929, and Lapparell Creek, Pike County, July 28, 1929, both records by Trautman. The latter is the most northerly record known.
Clinostomus (Leuciscus) elongatus (Kirtland).
Opsopoeodus emiliæ Hay. (Includes *O. megalops* Forbes).
Notropis heterodon (Cope).
Notropis anogenus Forbes. First taken in Ohio by C. Rutter at Port Clinton and Lakeside, 1898. Rediscovered by Osburn in Catawba Island "harbors" in 1929, though a specimen taken by Trautman

in Lake Erie at Port Clinton in 1927 has been found in a collection at the Ohio State Museum. The species is apparently limited to the shallow weedy waters adjacent to Lake Erie.

Notropis atrocaudalis heterolepis Eigenmann and Eigenmenn (*N. cayuga*, part).

Notropis atrocaudalis atrocaudalis Evermann (*N. cayuga*, part).

Notropis volucellus volucellus (Cope). (Includes also some of Osburn's *N. blennius*). It is the common variety over the state.

Notropis volucellus buchanani Meek. Larger streams of the extreme southern part of the state.

Notropis deliciosus missuriensis (Cope). (*N. blennius*, part). This variety has a more westward distribution but enters Ohio through the Maumee system into the western end of Lake Erie and also occurs in south-western Ohio, in more or less typical form.

Notropis deliciosus stramineus (Cope). (*N. blennius*, part). General throughout the state, but most typical in the eastern and north-eastern portions.

Notropis boops Gilbert. (*N. shumardi* Girard).

Notropis dorsalis dorsalis (Agassiz). First taken by Wickliff in Black River, Loraine County, August 7, 1922. Later records by Trautman, Hine and Walker in Cuyahoga, Medina and Summit counties.

Notropis blennius (Girard). (*N. jejunus* Forbes).

Notropis hudsonius hudsonius (Clinton).

Notropis whipplii spilopterus (Cope). (*N. whipplii* Girard).

Notropis ariommus (Cope).

Notropis atherinoides Rafinesque.

Notropis photogenis (Cope). (*N. arge* Cope).

Notropis rubellus (Agassiz). (*N. rubrifrons* Cope).

Notropis cornutus chrysocephalus (Rafinesque). The dominant subspecies, found practically over the whole state.

Notropis cornutus frontalis (Agassiz). Only in the coldest, most northerly situations in the state, especially the small, cold, hill streams of eastern and north-eastern Ohio.

Notropis umbratilis cyanocephalus (Copeland). (*N. u. lythrurus* Jordan, part). The only "redfin" found in the lake drainage. It also occurs in the northern part of the Ohio River drainage.

Notropis lythrurus (Jordan). (*N. u. lythrurus*, part). This species occurs in the south western part of the state. In previous reports it was confused with the preceding.

Ericymba buccata (Cope).

Phenacobius mirabilis (Girard). First taken by Osburn and Wickliff at Lake St. Marys, July 26, and in Big Walnut Creek, September 9, 1920. Later Wickliff and Trautman have found it not uncommon in the western half of the state, especially in the Scioto and Maumee systems.

Exoglossops lauræ Hubbs (MSS.) (*Exoglossum maxillingua* LeSueur). This species, first recorded in Osburn's report has been separated from Exoglossum and made a new genus and species by Hubbs. It has been taken again near the place where Osburn found it.

Notemigonus (Abramis) crysoleucas crysoleucas (Mitchill).

Hybognathus nuchalis Agassiz.
Chrosomus erythrogaster erythrogaster Rafinesque.
Hyborhynchus (*Pimephales*) *notatus* (Rafinesque).
Pimephales promelas Rafinesque.
Hypargyrus velox Girard. (*Cliola vigilax* Baird and Girard).
Campostoma anomalum (Rafinesque).

Family Ameiuridæ. Catfishes.

Ictalurus furcatus (LeSueur).
Ictalurus punctatus (Rafinesque).
Villarius (*Ameiurus*) *lacustris* (Walbaum).
Ameiurus melas melas (Rafinesque).
Ameiurus nebulosus (LeSueur).
Ameiurus natalis (LeSueur).
Pelodictis limosus Rafinesque. (*Leptops olivaris* Rafinesque).
Noturus flavus Rafinesque.
Schilbeodus gyrinus (Mitchill).
Schilbeodes nocturnus (Jordan and Gilbert). Recorded from a single specimen taken by Wickliff in Ottawa County, near the mouth of the Portage River, June 27, 1929. This is the first record of the species from the Great Lakes drainage.
Schilbeodes furiosus (Jordan and Jenkins). Taken by Trautman, July 3, 1927, in Shade Creek, Meigs County, and in the lower reaches of the Scioto and Muskingum rivers in 1929. Formerly known only from the Neuse, Tar and Little rivers of North Carolina, the species has also recently been noted for Indiana and Michigan by Hubbs.
Schilbeodes miurus (Jordan).
Schilbeodes eleutherus (Jordan).

Family Umbridæ. Mud Minnows.

Umbra limi (Kirtland).

Family Esocidæ. Pikes.

Esox (*Lucius*) *vermiculatus* LeSueur.
Esox (*Lucius*) *lucius* L.
Esox (*Lucius*) *masquinongy masquinongy* (Mitchill). (Part, L. Erie drainage).
Esox (*Lucius*) *masquinongy ohiensis* Kirtland. (Part, Ohio River drainage).

Family Anguillidæ. Eels.

Anguilla bostoniensis (LeSueur). (*A. chrysypa* Rafinesque).

Family Cyprinodontidæ. Killifishes.

Fundulus diaphanus menona (Jordan and Copeland).
Fundulus dispar (Agassiz).
Fundulus notatus (Rafinesque).

Family Percopsidæ. Trout Perches.

Percopsis omiscomaycus (Walbaum). (*P. guttatus* Agassiz).

Family Aphredoderidæ. Pirate Perches.

Aphredoderus sayanus (Gilliams).

Family Moronidæ. White Basses.

Lepibema (*Roccus*) *chrysops* (Rafinesque).

Family Percidæ. Perches.

Perca flavescens (Mitchill).
Stizostedion canadense canadense (Smith). (*S. c. griseum* DeKay).
Stizostedion vitreum (Mitchill). (*S. vitreum*, part).
Stizostedion glaucum Hubbs. (*S. vitreum*, part). The blue pike-perch of Lake Erie, especially in the eastern part of the lake.

Family Etheostomidæ. Darters.

Hadropterus evides (Jordan and Copeland).
Hadropterus maculatus (Girard). (*H. aspro* Cope and Jordan).
Hadropterus phoxocephalus (Nelson).
Hadropterus scierus Swain.
Percina caprodes caprodes (Rafinesque).
Percina caprodes semifasciata (DeKay) (*P. c. zebra* Agassiz). In the most typical form only in Lake Erie.
Cottogaster copelandi (Jordan).
Imostoma (*Cottogaster*) *shumardi* (Girard).
Ammocrypta pellucida (Baird).
Crystallaria asprella (Jordan).
Boleosoma nigrum nigrum (Rafinesque).
Poecilichthys (*Etheostoma*) *variatus* Kirtland.
Peocilichthys (*Etheostoma*) *camurus* Cope.
Peocilichthys (*Etheostoma*) *zonalis* Cope.
Peocilichthys (*Etheostoma*) *coeruleus* (Storer).
Peocilichthys spectabilis (Agassiz). (*Etheostoma coeruleus spectabile*).
Peocilichthys (*Etheostoma*) *tippecanoe* Jordan and Evermann.
Peocilichthys exilis (Girard). (*Boleichthys fusiformis* Girard).
Catonotus (*Etheostoma*) *flabellaris flabellaris* (Rafinesque).
Microperca punctulata Putnam. First taken by Wickliff and Osburn in Turkeyfoot Lake, August 7, 1920; and later by Trautman in Blue Creek, Erie County and Nettle Lake, Williams County.
Etheostoma (*Diplesion*) *blennioides* Rafinesque.

Family Centrarchidæ. Black Basses and Sunfishes.

Micropterus dolomieu Lacepede. (Part).
Micropterus pseudaplites Hubbs. This recently described species, the "Kentucky Black Bass," separated from the preceding, is found to be the dominant Bass of the rivers of extreme southern Ohio, taken in about 18 counties, where it prefers the quieter waters.

Aplites (*Micropterus*) *salmoides* (Lacepede).
Chaenobryttus gulosus (Cuvier and Valenciennes).
Apomotis cyanellus (Rafinesque).
Helioperca incisor (Cuvier and Valenciennes). (*Lepomis pallidus* Mitchill).
Xenotis (*Lepomis*) *megalotis megalotis* (Rafinesque Part).
Xenotis (*Lepomis*) *megalotis peltastes* (Cope). This subspecies occurs in the lake drainage of Ohio.
Allotis (*Lepomis*) *humilis* (Girard).
Eupomotis heros (Baird and Girard).
Eupomotis gibbosus (L.).
Ambloplites rupestris (Rafinesque).
Pomoxis annularis (Rafinesque).
Pomoxis sparoides (Lacepede).

Family Atherinidæ. Silversides.

Labidesthes sicculus Cope.

Family Sciaenidæ. Croakers, Drumfishes.

Aplodinotus grunniens Rafinesque.

Family Cottidæ. Sculpins.

Cottus bairdii bardii Girard. (*C. ictalops* Rafinesque).
Cottus ricei Nelson. A single specimen by Wickliff and Tidd in Lake Erie, near Kelley's Island, November 7, 1928. It is common farther east in the deeper waters of the lake.

Family Gasterosteidæ. Sticklebacks.

Eucalia inconstans (Kirtland).

Family Gadidæ. Codfishes.

Lota maculosa (LeSueur).

TWO OHIO SUBTERRANEAN ASCOMYCETES AND THEIR ASCOMYCETOUS PARASITES.*

W. G. STOVER AND M. M. JOHNSON.

The genus Cordyceps is of considerable interest to mycologists and to other naturalists. Most of the species are parasites of insects, the fruiting bodies developing on the larval or pupal stages, and in some species on the adult stage, of the insect (5, 6). The species most commonly found is *C. militaris* (L.) Link which occurs on buried pupæ and larvæ. The writers, and others, have collected it in Ohio several times in recent years. The fruiting body is a slender, firm but fleshy structure, one to two inches tall and orange-yellow in color. The upper portion is covered with pimple-like papillæ which mark the position of the embedded perithecia containing the numerous asci, each with its eight slender ascospores. The genus is placed in the pyrenomycetous order, Hypocreales.

There are two species of Cordyceps, however, which are parasitic on certain fungi belonging to the genus Elaphomyces. The species of Elaphomyces are all subterranean. The mycelium of some of them forms mycorrhizas with the roots of coniferous trees, species of pine being most frequently mentioned. Dodge (1), in his recent monograph, lists 24 known species, of which he reports eight to occur in America with an additional doubtful record. Only two of these, *E. muricatus* Fr. (from Michigan) and *E. variegatus* Vitt. (from Iowa), have been reported from the north central states.

The fruiting body of the species of Elaphomyces is more or less globose and covered with a relatively thick rind of three distinct layers: The *crust* or outer layer, the *cortex* or middle layer and the *peridium* or inner layer. The spores are borne in asci which occur in scattered groups throughout the central portion of the fruiting body. The asci disappear after the spores are formed and the mature fructification is more or less completely filled with a brown powdery mass of spores. This genus is included in the order Aspergillales of the Plectomycetæ.

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While collecting fungi in the deep ravine below Old Man's Cave in Hocking County, Ohio, on August 15, 1925, the writers found a specimen of clavate Cordyceps. Upon removing it from the soil, it was discovered to arise from a globose subterranean fungus having much the appearance of a golf ball except as to color. This was later determined as *Elaphomyces variegatus* Vitt. The next day about a dozen other specimens of this species were found in the same ravine on a rock ledge covered with well-decayed leaf mold. Other collections have been made since as recorded below.

On October 9, 1926, a capitate Cordyceps was collected near Sugar Grove, Fairfield County, Ohio. This specimen developed from the buried fruiting body of another species of Elaphomyces which was later determined as *E. anthracinus* Vitt. After taking field notes on these collections, the specimens were preserved in 7% formaldehyde, and later studied more fully in the laboratory.

These collections are of particular interest because, so far as we have been able to learn, none of the species has been previously reported for this region. *E. anthracinus* has been reported in America only from Tennessee and North Carolina; *E. variegatus* is here recorded from the Ohio Valley for the first time, while neither of the species of Cordyceps has hitherto been reported west of the Alleghenies. The ranges of all four of the species discussed is therefore considerably extended.

Elaphomyces variegatus Vitt.

The fruiting body is subterranean; globose, subglobose or somewhat flattened; 1-3 cm. in diameter; yellowish-brown, and covered with warts of the same color. The warts are about as broad as high and rounded at the tips. Their bases are mostly pentagonal or hexagonal, although the smaller ones are often triangular. The peridium is quite thick and firm, and brownish-rose in color. In sections of the peridium there are reddish-brown reticulations plainly to be seen throughout its thickness. No asci were found in any of the specimens examined, but the characteristic dark-brown ascospores were quite abundant, filling the whole interior. According to our measurements the spores are 18-21 microns in diameter.

Our specimens were found in well-decayed leaf mold, two to four inches beneath the surface, in a damp ravine at Old Man's Cave, Hocking County, Ohio; Stover and Johnson, August 15, 16, 1925; Johnson and Dobbins, August 29, 1926; Stover, Johnson and Humphrey, September 10, 1927.

This was at first assumed to be *E. cervinus* (L.) Schlecht., probably the most common species of the genus, and frequently referred to in the literature as *E. granulatus* Fr. After microscopic examination, however, our specimens were determined to be *E. variegatus* Vitt. as interpreted by Dodge (1). In both species, the "crust" or outer mycelial layer, is readily separated and therefore not usually seen. The peridium, or inner layer of the rind, is markedly different in the two species, however. In *E. variegatus*, it is described as being grayish-rose to chestnut in color and "marbled with reddish-brown reticulations." In *E. cervinus* the peridium is white and without reticulations. The spores of the latter species are considerably larger, measuring 26-30 microns in diameter. Our specimens agree with Dodge's description of *E. variegatus* in all essential respects. He does not mention the triangular bases of the smaller warts and we were not able to demonstrate a "yellow gel" surrounding the warts, perhaps on account of the preservation of the specimens in formaldehyde.

According to Dodge, *E. variegatus* has previously been collected in southern Europe, New England, Florida and Iowa. Lewton-Brain (3) studied material collected in Scotland. He, as well as others, states that it forms a mycorrhiza with the roots of pine and other conifers. No observations were made by the writers on this point, but hemlock trees were growing near the place of collection and it is quite possible that a mycorrhizal relation had been established between the mycelium of the fungus and the roots of the hemlock. The yew (*Taxus canadensis* Marsh) also occurs in that part of the ravine, while two species of Pinus grow on the hills just above the ravine.

Most of these specimens were parasitized by *Cordyceps parasitica* (Willd.) Seaver which is described below. In fact the latter fungus was seen first and the Elaphomyces was found only upon removing the Cordyceps from the soil. A few of the fruiting bodies had no parasites attached.

Elaphomyces anthracinus Vitt.

The fruiting body is subterranean, globose, about 1.3 cm. in diameter and dark brown to black in color. The outer layer, the crust, is readily separated from the hard, fragile, carbonaceous cortex. The peridium, or inner layer of the rind is thick, white, with a dark line near the middle, and cottony in texture. The interior is filled with the dark spore-bearing portion. No asci were found in our specimen. The spores

are brown to dark brown, globose, 15-20 microns in diameter according to our measurements. The outer surface is often thickly studded with fine points or prickles.

This species was collected by the writers at Sugar Grove, Fairfield County, Ohio, October 9, 1926. The single plant was found in a damp ravine, about two inches beneath the surface of well-decayed leaf mold. There are hemlock trees in the immediate vicinity and pines on the hill just above the ravine. The specimen agrees very well with Dodge's (1) description of *E. anthracinus*. Our plant was parasitized by *Cordyceps agariciformia* (Bolt.) Seaver, which is described below.

Although apparently fairly common in central and southern Europe, this species has been previously reported in this country only from Tennessee and North Carolina, according to Dodge (l. c.)

Cordyceps parasitica (Willd.) Seaver.

The fruiting body or stroma consists of a cylindrical stalk and a club-shaped fertile portion or head. The whole fruiting body becomes very dark brown or black. In some of our specimens the stalk or its base was deep yellow or golden-orange when collected but became black later. The head is somewhat broader than the stalk; usually compressed laterally, but sometimes nearly circular in cross section; when compressed, usually narrowly elliptical in outline; rounded at the apex and narrowed gradually toward the stalk; 1.5-2.5 cm. high and 3-9 mm. across; clearly differentiated from the stalk, and covered with numerous small papillæ which mark the position of the ostioles of the embedded perithecia.

The stalk is slender, usually cylindrical, nearly smooth or sometimes longitudinally striate under the lens; 2.5-9 cm. long and 2-4 mm. in diameter; apparently branching at the base into a several root-like mycelial strands or rhizomorphs which extend through the soil and are attached to fruiting bodies of *Elaphamyces variegatus* Vitt.

The ascospores are filiform and nearly as long as the slender ascus which contains them; many-septate, at maturity breaking up into segments only slightly longer than broad.

Our plants were parasitic on fruiting bodies of *Elaphomyces variegatus* Vitt. in a damp ravine at Old Man's Cave, Hocking County, Ohio: Stover and Johnson, August 15, 16, 1925; Johnson and Dobbins, August 29, 1926; Stover, Johnson and Humphrey, September 10, 1927; Stover and Miller, October 12, 1929.

This fungus occurs in Europe and, as recorded by Seaver (5, 6), its American distribution is "Ontario to Rhode Island and Virginia."

C. parasitica is quite similar in appearance, size, shape and color to certain species of the Geoglossaceæ, but is readily distinguishable on account of the pimple-like papillae covering the upper portion of the fruiting body.

This species and the following are the only members of the genus Cordyceps known to occur as parasites on fungous fruiting bodies. Lloyd (4) points out that these two species differ not only in the shape of the fruiting body (stroma) but also in their method of attachment to their hosts, and in the character of the ascospores. In our specimens of *C. parasitica* the mycelial strands are a prominent feature. They are much branched and sometimes several centimeters long. When fresh they were deep yellow but became very dark brown or black after preservation. This fact, with other observations on the color, recorded above, leads us to believe that the whole fruiting body is probably yellow to orange when young.

Cordyceps agariciformia (Bolt.) Seaver.

The fruiting body or stroma in our specimen is 7 cm. tall and consists of a sterile stalk and a cap-like head or fertile portion. The ovoid head was about 1 cm. in diameter, yellowish below to brown and blackish above and somewhat shining when fresh. The entire surface of the head is covered with numerous papillæ which contain the ostioles of the embedded perithecia. The stalk was yellow when fresh but the whole plant is black since being preserved. The stalk is 5 mm. in diameter at the base, tapering somewhat toward the apex, smooth below and somewhat scaly above. The asci are slender and cylindrical; the ascospores are filiform, nearly as long as the ascus and are said to break up into rather long segments when mature.

This species was collected by the writers October 9, 1926, at Sugar Grove, Fairfield County, Ohio. The single specimen found was parasitic on *Elaphomyces anthracinus* Vitt., developing directly upon it without any mycelial strands such as those found in *C. parasitica* (Willd.) Seaver. It will be noted that the stalk and lower part of the head were yellow or yellowish when collected and later became black. It seems probable that the head, although black in our specimen when collected, is at first some shade of yellow. Seaver (5, 6) however, states that it is reddish-brown. The distribution, as recorded by

Seaver (l. c.) is "Maine to Ontario and Florida." Lloyd (4) and Hard (2) discuss and illustrate the fungus under the name *C. capitata* (Holmsk.) Link, formerly often used.

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PHYSICS AS A CULTURAL SUBJECT.*

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The traditional attitude of the physicist toward cultural courses in general and a cultural course in physics in particular has been one of relative indifference. Not that he has disclaimed any desire for culture, but he has regarded culture as a by-product to be obtained while seeking something more worth while. He has associated "cultural" with courses that are decidedly weak in content—for example, in physics non-mathematical descriptive courses. Among his other objections to a course for which nothing better could be said than that it is "cultural" has been that the word "cultural" does not admit of the rigorous definition that he has been accustomed to apply to his concepts. It is subjective, while he has regarded his interests as essentially objective. However recent developments in physics have obliterated what was formerly considered to be the sharp boundary between the objective and the subjective. Other developments have made him a little less certain of the absolute character of his knowledge. With these realizations—though perhaps independently—has come a more human point of view. A physics department head in a prominent university recently deplored the fact that physics made so small a contribution to the cultural development of the average undergraduate. Such concern would have been rare a few years ago. An undergraduate national physics fraternity has lately been sponsored by eastern physicists, one of the aims of which is to promote a greater appreciation of physics. Witness too the number of books that leading physicists have written for the layman since 1928. Evidently physicists are having increased interest in cultural considerations.

What then should be the proper criterion of the cultural course? It must be the degree to which it provokes thought and develops permanent interests rather than the degree of difficulty with which it is assimilated; the extent to which the

* An invited paper before the Physics Section of the Ohio Academy of Science, April 18, 1930.

student may be induced to work beyond the definitely assigned and formal tasks; and when he has finished the course and received his credit and grade does he forget it as he would a bad dream, or does it color the whole of his thinking; has the seeking of new knowledge on the subject become one of the avocations of his life; does it fortify leisure hours against dissipation. What study can compare with physics in these tests, yet how many students have left the subject of physics without being in the least impressed!

Of what does the cultural course in physics consist? It is not a compendium of facts. Facts attain cultural value only as they become materials for thought. The student in the cultural course must be given ample exercise in the manipulation of the facts he has learned. Now the ideas in physics are essentially mathematical, and before the student can do any constructive thinking in the subject, he must have at least some working knowledge of mathematics. A purely descriptive course is then ruled out. In such a course he can only give back parrot-fashion the facts he has heard or read, lacking even the ability to evaluate them. For a similar reason a popular demonstration course must be rejected, as well as for the additional reason that no physicist can compete with a magician in making a spectacular exhibition. Is the cultural course then rigorously mathematical? In no case would general physics taught on an exclusively mathematical basis have the highest cultural value. The function of the mathematics is that of a skeleton in holding vital elements together. The application of the mathematical developments to the physical ideas must be brought out in innumerable ways. Many instructors omit numerous simple applications as being altogether obvious, but they are not obvious to the average student, and the cultural course must not lack appeal to the average student. Class demonstrations are of the utmost value in illustrating the physical significance of the mathematical formulae. The illustrations and demonstrations not only add to the student's interest, but they justify in his mind the introduction of the mathematics. But how deeply into mathematical methods the instructor should go probably has no objective answer. A course is not cultural for any student if a considerable portion of his study is in memorizing formulae which he does not comprehend. But for that matter neither would it be of great value to him as a technical student.

A physics professor in a state university said some years ago, "If college physics (by which he undoubtedly meant cultural physics) is to persist, it must divest itself of its mathematical formulation." We can see in this statement little if any foundation in fact. No one has ever questioned the permanence of mathematics as a cultural subject, and if the mathematical student can not be interested in physics and if the physics course does not create a desire to know mathematics even where none existed before, there is something wrong with the course and it ought to perish. The most common trouble in our opinion is that there is far too little mathematics in the physics course. Perhaps the department does not have sufficient mathematical prerequisites for its courses, and as a result the instructor is more or less apologetic in introducing the mathematics. Even with prerequisites in college mathematics, there are many necessary mathematical ideas which the student seldom learns in the mathematics department. One of these concepts is functionality. Few students entering college physics even after two years of college mathematics know how to build up an expression for the dependent variable in terms of the independent variables though they are told the laws governing the independent variables. A rigorous presentation of mechanics in the general course furnishes opportunity for a vast amount of drill in fundamental mathematical concepts, and for a great deal more in associating the abstract mathematics with the physical ideas. In the derivation of the formulae every assumption and every approximation must be clearly pointed out, and a sharp distinction made between the experimental and the theoretical bases. Considerable use of dimensional equations is highly profitable. Admitting that this portion of the work rates low culturally for many students—(cultural is subjective), the students must be made to learn this technique by any methods found to be effective. The ability to use has high cultural value though the *process* of learning it may be almost as lacking in cultural value as the *process* of learning the alphabet or of learning to read.

In many physics departments the inferior student receives small consideration, irrespective of whether the reason for his inferiority is inability, laziness, or deficient back-ground due to early lack of opportunity. Many of the latter group are highly deserving. A little investigation shows a rather large percentage of these students with deficient back-ground to be

science teachers in the public schools or even high schools. If we do nothing for them, we have ourselves to blame for the unsatisfactory teaching in the secondary schools of which we all complain, and the vicious circle will persist. Often it is impossible to give them a great deal of individual attention, but the introducing of each new subject by simple qualitative ideas is of the greatest value to these students. Furthermore this practice is not without value to the superior student in aiding him to connect up the familiar with the unfamiliar, and in no case, if the qualitative ideas are presented in a concise interesting way, is the attention of the superior student lost. There is on the other hand no place for sluggards and drones in the cultural physics course.

When the class has learned sufficient mathematical technique to use in a constructive way, the instructor may discard his driving methods, substituting therefor inspirational methods. Nor do these preclude giving in the general course such derivations as the equation of the adiabatic and Carnot's cycle. However the student must previously be given some comprehension of isothermal, adiabatic, and graphical representation of work, or he will have a mass of material that he can only memorize.

We have made the average student the determining factor in the presentation of the cultural course. But when his needs are given proper consideration, the whole class may be carried to greater heights, and hence this course is best for the superior student as well.

Something should be said concerning the qualifications of the teacher of the cultural course. In addition to the qualifications commonly emphasized, he should be interested in people and in the way in which their minds work. Fully realizing the mental deficiencies of his students, he needs endless patience in dealing with them, and he can use the zeal of a reformer.

Finally, the qualifications of the teacher of the cultural physics course and those of the course itself are the very ones that make it the most valuable for the technical student as well.

DRAINAGE CHANGES IN THE TOLEDO REGION.*

J. ERNEST CARMAN,
Ohio State University.

General Characteristics of the Drainage.

The surface south of the west end of Lake Erie in Ottawa, Sandusky, Wood and Lucas counties is a very flat plain which slopes gently northeastward toward the lake at about 5 feet per mile. This plain is the old lake bed of Lake Erie extended, as it existed during the retreat of the Wisconsin glacial stage.

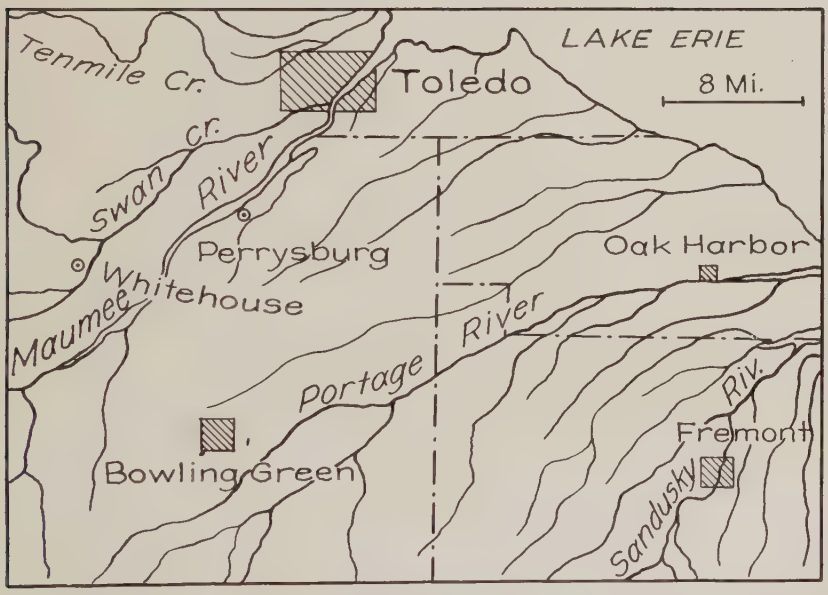

Fig. 1. Map of a portion of northwestern Ohio showing the closely-spaced, parallel, northeastward-flowing streams.

The drainage of the region is by closely-spaced, parallel, northeastward-flowing streams which originated as *consequent streams* on the flat plain as the Pleistocene, ice-border lake withdrew to the present Lake Erie (Fig.1). On this even surface, with very gentle but uniform slope, many of the

*Published with the permission of the director of the Geological Survey of Ohio.

originating streams flowed for great distances parallel with each other, without uniting, although only a mile or two apart.

The Maumee River, the major stream of the region, was formed along the axis of the old lake basin, chiefly by waters which entered the region from the west, but the floor of the median part of the basin had so little slope toward the axis that smaller streams originated and flowed northeast in the direction of the axis, parallel with, though only a short distance from, the far greater Maumee. At the time of the origin of the drainage, the Maumee received no tributaries from the northwest from the southwest corner of Lucas County northeast to its mouth, a distance of 30 miles, and no tributaries from the southeast north of Waterville, a distance of about 20 miles. The two streams which now join the Maumee within these intervals, Swan Creek on the northwest and Otter Creek on the southeast, are both interpreted here as cases of stream capture.

Swan Creek.

Swan Creek heads in Fulton County to the west and, in conformity with the general slope of eastern Fulton and western Lucas counties, flows southeast to near Whitehouse in southwestern Lucas County. Here, at about 3 miles from the Maumee River, it changes direction and flows northeast for about 15 miles parallel with the Maumee River which it joins at Toledo (Fig. 1). This lower, northeastward-flowing course of Swan Creek is a continuation of the course of South Swan Creek which enters at the bend near Whitehouse and these two parts together make a drainage course 25 miles long from the southeast corner of Fulton County to Toledo, parallel with and only 2 to 4 miles from the Maumee River.

A low linear course, occupied largely by a marsh, runs northeast from the Ann Arbor Railway Station on Cherry Street in Toledo to Maumee Bay, parallel with but definitely separated from the Maumee River by a narrow belt of upland one-half mile or less in width (Fig. 2). Its linear form, flat floor, and definite, bounding slopes show plainly that this low course was made by stream erosion but no stream competent to do the work occupies it now, or could have received sufficient water for the work from the few square miles tributary to this depression.

The interpretation offered is that Swan Creek did not formerly join the Maumee River at Toledo, but continued on northeast along this low course to an independent terminus at the head of Maumee Bay. Near the present mouth of

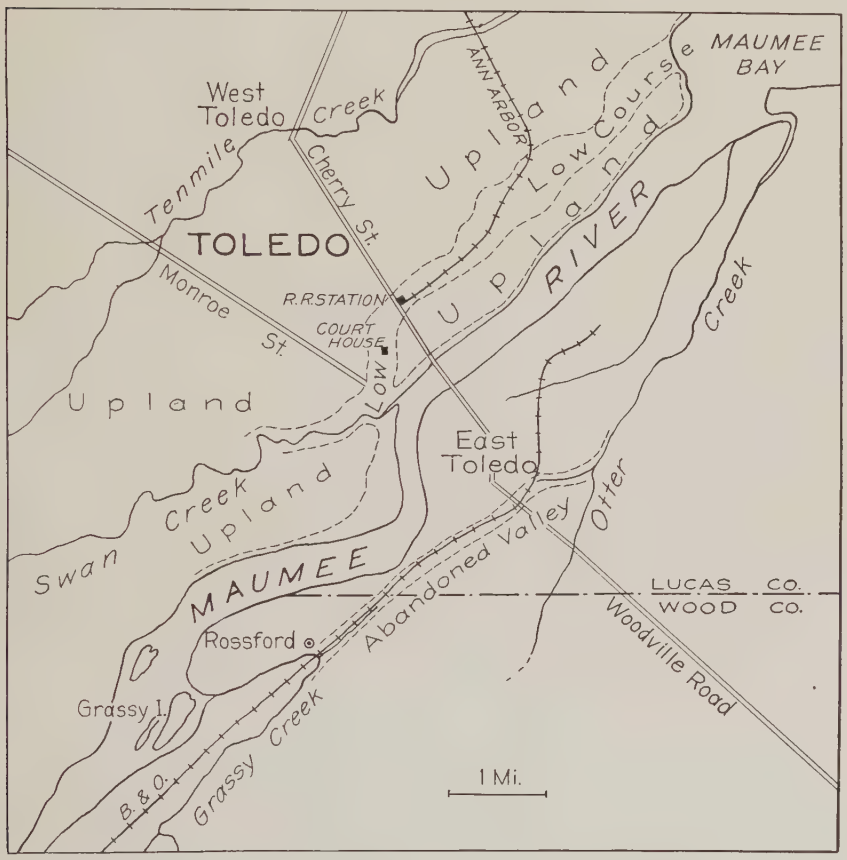

FIG. 2. Map of the Toledo region showing the drainage changes of Swan Creek and Grassy Creek as discussed in the text.

Swan Creek in Toledo the belt of upland between the two valleys was so narrow that the combined undercutting by the streams on the outer curves of loops opposite each other cut completely through the intervening divide and Swan Creek entered directly the larger stream, and thus abandoned its lower course northeast of Toledo (Fig. 2).

The former course of Swan Creek through the down-town part of Toledo is partly obscured by filling and grading but close observation shows definite topographic evidence to support the foregoing interpretation. The former course left the present Swan Creek near the St. Clair Street bridge and, continuing on northeast, crossed Monroe Street near Superior Street, crossed Madison Street near Erie Street, passed across the site of the Court House and the City Prison, and crossed Cherry Street at Seneca Street at the Ann Arbor Railway Station. This course leads through the down-town section of Toledo. It was formerly followed by the Miami and Erie canal. Northeast of Cherry Street the course is very definite as noted in the foregoing.

The points of the severed upland are shown on the south by the higher land that begins just south of the St. Clair Street bridge and on the north by the elevation which begins on Summit Street near Jefferson Street. Between these limiting points, about three-eighths of a mile apart, the undercutting of the divide between Maumee River and the former Swan Creek took place, resulting in the diversion of Swan Creek.

The particular type of stream piracy illustrated here by which two streams cut laterally until their valleys unite, is called *planation stream piracy*.* The Maumee River was the *pirate*. Swan Creek is the *diverted stream*. That part of the former valley from Toledo to Maumee Bay that was left without a stream is an *abandoned valley*.

Grassy-Otter Creek.

Grassy Creek heads south of Perrysburg, Wood County, and flows northeast for about 7 miles parallel with, and only one mile or less from, the Maumee valley. Just southeast of Rossford the creek turns sharply to an acute angle of about 25 degrees and flows west-southwest for one and one-fourth miles, through a sharply cut valley, to the Maumee River, (Fig. 2). From the acute angle bend of Grassy Creek a low course, which is very evidently a stream-cut valley, continues on to the northeast through the south part of East Toledo and is occupied by the upper course of Otter Creek which enters Maumee Bay just east of the mouth of the Maumee River.

*1921. Malott, C. A. Planation Stream Piracy. Proc. Indiana Acad. Science, 1920, pp. 249–260.

From Rossford northeast through the south part of East Toledo this low course is followed by the Baltimore and Ohio Railway with extensive railway yards. In East Toledo, Navarre Park is located in this old valley. On northeast it is a distinct, flat-floored valley, much too large for Otter Creek which occupies it.

The existence of such a sharp angle bend, as that of Grassy Creek southeast of Rossford, suggests piracy, and the abandoned valley continuing northeast from the bend gives additional evidence. The interpretation offered is that Grassy Creek and Otter Creek were formerly one stream which originated on the gently sloping, lake plain and for 14 miles, from Perrysburg to the mouth of Otter Creek, had a course parallel with and only one-half to one and one-half miles from the Maumee River. A small tributary of this Grassy-Otter Creek headed within the area of the present Maumee valley at Grassy island and flowed northeast along the course of the present Grassy Creek reversed, joining Grassy-Otter Creek at the location of the present sharp angle of Grassy Creek. The Maumee River then cut laterally, forming the reentrant in which Grassy Island now lies, and in doing so it undercut that part of the plain containing the headwaters of the small tributary of Grassy-Otter Creek. The gradient of this tributary upon the plain was very low and some of its water at its undercut head flowed down the bluff of the Maumee valley and started a gully. Because of the much lower level of its mouth at the Maumee River, this gully had a far steeper gradient than the tributary of Grassy-Otter Creek and because it continually received water at its head from the valley of the tributary, it rapidly lengthened headward along the course of the tributary and, by a process which we may call *headwater piracy*, gradually reversed the direction of drainage of more and more of the tributary until the place of union of the tributary with Grassy-Otter Creek southeast of Rossford was reached. Here, the level of the head of the gully being below the level of Grassy-Otter Creek, the gully captured the creek and took its waters by the reversed course of its former tributary, west-southwest down the gully to the Maumee River.

The type of piracy illustrated here by which a rapidly eroding stream, like the gully, extends itself by *headword erosion* into the course of a more sluggish stream, like Grassy-Otter Creek, is known as *headword erosion piracy*. It is probably the most common type of piracy and is favored by

escarpments or steep bluffs, like those along the Maumee valley, in close proximity to streams which flow with gentle gradients upon a higher plain. In the geologic future many cases of this type of piracy should take place in the area bordering the

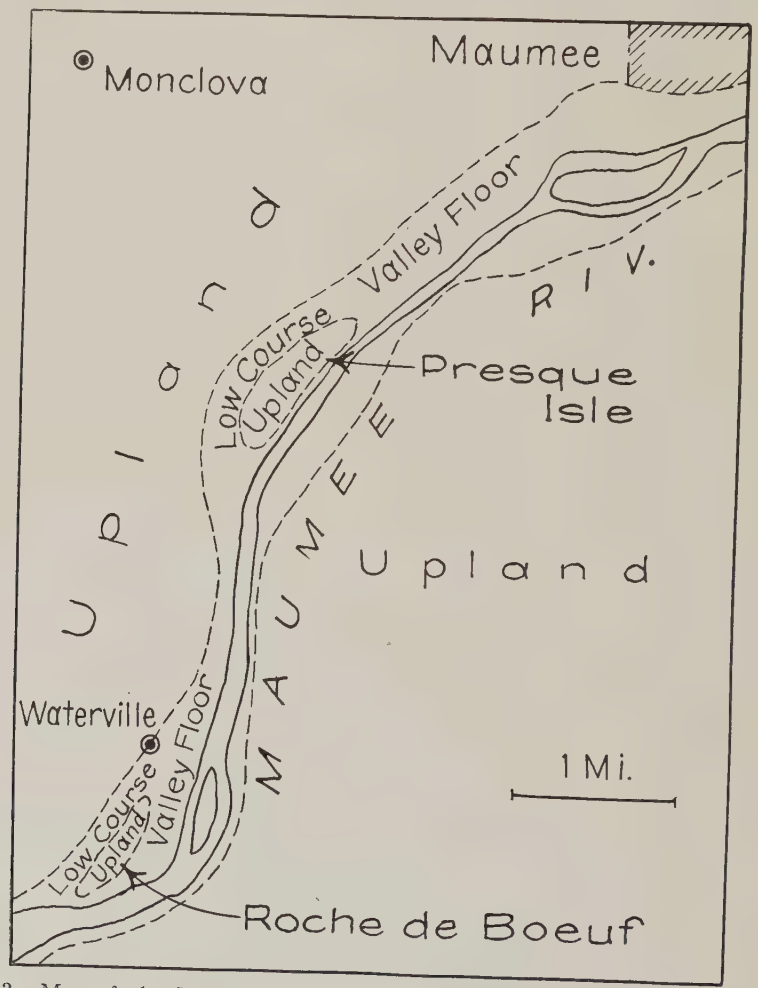

FIG. 3. Map of the Maumee River valley from Maumee southwest through Waterville showing the location of the island-like areas, Presque Isle and Roche de Boeuf, which are separated from the upland by low courses.

Maumee valley. The especial feature of this case is that the gully that did the capturing, the *pirate*, was apparently producing reversal of drainage by working headward along the course of a tributary of the stream which it finally captured.

Grassy Creek south of the sharp angle is the *diverted stream*. Otter Creek is the *beheaded stream*. The part of the former course for several miles northeast of the point of capture through the south part of East Toledo is an *abandoned valley* and the direction of drainage of the southern part of this abandoned course for at least a mile northeast of the place of capture has been reversed and now flows southwest.

Maumee River.

Three miles southwest of the village of Maumee there is, within the Maumee valley proper, an island-like elevation, known as Presque Isle, one mile long and less than one-fourth of a mile wide and rising to the level of the adjoining upland plain (Fig. 3). The river is on the east of Presque Isle in a rock channel, while on the west, Presque Isle is separated from the upland by an abandoned, flat-bottomed valley about one-fourth of a mile wide. The floor of this valley is on rock at 25 to 30 feet below the upland and about 20 feet above the river. Apparently the Maumee River lowered both valleys concurrently until the bed rock was reached when the valley on the east of Presque Isle acquired all the river and the valley on the west was abandoned.

A similar but smaller, elongate, island-like area which was known in an early day as Roche de Boeuf, exists in the Maumee valley south of Waterville at the north end of the Ohio Electric Railway bridge (Fig. 3). The abandoned valley on the west is followed here by the Miami and Erie canal. This is another case where the Maumee River cut a larger and smaller valley concurrently until the bed rock was reached when the larger valley on the east acquired the entire river.

A STUDY OF THE FOOD OF THREE FISH SPECIES FROM THE PORTAGE LAKES, OHIO.

HAROLD CASSIDY, ARTHUR DOBKIN, AND RALPH WETZEL.

Introduction.

By Walter C. Kraatz,
University of Akron.

During fish seining operations in the summers of 1926 and 1927, by the writer and assistants, many fishes, particularly minnows and other smaller types were secured from the Portage Lakes near Akron, Ohio.

Previously the writer published a paper on the food of the most abundant fish species of the lakes; (Kraatz: Study of the food of the blunt-nosed minnow, *Pimephales notatus*, Ohio Jour. Sci., Vol. XXVIII, No. 2, pp. 86–98, March 1928).

Food of any fish species of various localities is of interest in extending existing data on food habits, and it is thought desirable to publish food data on three other species from these lakes, but combined as one paper from the independent papers of the three student authors, to save repetition of introductions, etc. Discussion of details is largely omitted, as is a bibliography, which in this brief report is deemed superfluous. The methods of food study were the same standard methods employed in the above-mentioned paper in which they are sufficiently described.

Opsopoeodus emiliæ was the second most abundant minnow in the lakes during the collecting period, and Notemigonus (Abramis) crysoleucas was third. The "top minnow," *Fundulus diaphanus menona*, is of special interest because in this group of lakes it is found only in Turkeyfoot Lake, and in Ohio in general, only in the very northern part, and has been principally reported from Lake Erie bays and streams leading into them.

Food of the Minnow *Opsopoeodus emiliæ*.

By Harold Cassidy.

Only 32 specimens were studied, but the diets of these were so similar that they can be regarded as representative for these waters. Of these specimens 27 were from New Reservoir, 4 from Turkeyfoot Lake, and 1 from Nesmith Lake.

This minnow, (Table I), seems to have a preference for an animal diet as attested by the large number of Chironomidæ larvæ, Cladocera and Ostracoda ingested. The plant material may have been ingested largely as incidental material in the feeding. Noting the large number of midge larvæ eaten, a few were examined as to their food, and found to contain chiefly diatoms, Scenedesmus and some filamentous green algæ, all of which were likewise found free but in very small proportions in the minnow intestine. Opsopoeodus having principally an animal diet, more so than Pimephales notatus, is therefore more in competition with game fishes in their early stages. However no more than Pimephales does it in any way destroy young fishes in their early stages, and it also forms a link in the chain of converting plankton to a form available to the larger game fishes.

Food of the Golden Shiner

Notemigonus (Abramis) *crysoleucas.*

By Arthur Dobkin.

A series of 40 Portage Lakes specimens were studied, distributed as follows: New Reservoir, 34; East Reservoir, 4; Turkeyfoot Lake; 2.

This minnow, (Table II), seems to have preference for an animal diet. This is at least certain in specimens of the small size available from these particular waters, though it has been evident from other studies that considerable variability in food may exist. Cladocera formed by far the largest food type with Ostracoda second. In some cases Copepoda and in a few algæ were common. Thus it was feeding almost entirely on plankton, and only 4 specimens showed by inorganic debris ingested, a bottom feeding habit. The golden shiner is another good example of a fish suitable for converting plankton into food for larger game fishes.

Food of the Menona Top Minnow,

Fundulus diaphanus menona.

By Ralph Wetzel.

All specimens of the species collected were from Turkeyfoot Lake, and 40 were examined for food. These were all more than half grown and mostly mature. Many females carried eggs, and the intestinal contents in these were meagre. In one specimen virtually nothing was found.

It is of course apparent, (Table III), that this fish is a plankton feeder. Various Entomostraca formed outstanding food items, and in a very large number of cases, Amphipoda were prominent. The latter was the genus Hyalella so common in these waters, mostly on vegetation just a little submerged in shallow water. Very little phytoplankton was eaten, and in these specimens at least the food is principally larger animal plankton.

TABLE I.

Opsopoeodus emiliæ.

Percentage Composition of Alimentary Canal Contents.

Locality	Date	Length of Fish, mm.	Length of Intestine, mm.	Degree Filled	Inorganic	Plant Debris	Blue-green algae	Diatoms	Desmids	Scenedesmus	Green algae	Higher Plant Remains	Statoblasts of Bryozoa	Copepoda	Cladocera	Ostracoda	Chironomid Larvae	Insect Eggs	Insects (Various)	Animal Debris
New Reservoir	7/15/26	47	27	.25	5	2	1	1	....	1	1	....	....	....	30	5	50	....	....	4
	"	50	33	.20	1	9	1	1	1	1	1	....	....	....	5	....	60	....	....	20
	"	51	25	.25	1	....	1	1	....	2	1	....	....	....	4	....	30	....	60	....
	"	48	40	.25	1	....	1	1	1	1	3	....	....	....	2	....	65	....	....	25
	"	51	25	.15	1	....	1	1	1	1	1	1	....	....	....	....	50	....	....	43
	"	45	34	.15	4	....	1	1	....	1	1	....	....	....	2	....	60	....	....	30
	"	52	27	.15	1	....	1	1	....	1	1	....	....	....	10	....	....	....	....	85
	7/22/26	50	30	.50	....	12	....	1	....	1	1	....	....	....	5	10	20	5	....	45
	"	50	30	.50	1	5	1	1	....	1	1	....	....	....	....	5	40	....	....	45
	"	53	30	.60	....	10	....	1	....	1	2	....	....	....	....	....	40	1	....	45
	"	56	29	.25	....	....	....	1	....	1	1	....	....	....	3	5	70	....	....	19
	"	55	35	.33	....	1	....	1	....	1	2	....	....	....	11	....	70	....	....	15
	"	45	30	.85	....	....	....	....	....	....	....	....	....	....	80	7	3	....	1	9
	"	46	25	.75	....	....	....	....	....	....	....	....	....	....	1	1	20	....	70	8
	"	49	27	.60	....	7	....	1	....	2	15	....	....	....	....	....	70	....	....	5
	"	45	35	.90	....	2	....	1	....	1	1	....	....	....	35	5	55	....	....	....
	"	44	24	.50	....	....	....	1	....	1	....	....	....	....	20	8	60	....	5	5
	"	50	25	.0	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
	"	46	26	.75	....	2	1	1	....	1	....	....	....	....	....	....	35	10	....	50
	7/29/26	48	27	.20	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
	"	48	26	.20	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	100
	"	46	22	.60	....	....	1	....	....	....	1	....	....	....	....	40	25	....	....	....
	"	55	33	.40	....	....	5	1	....	....	5	....	....	....	5	4	....	....	....	80
	"	49	23	.40	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	100
	"	48	32	.30	....	10	5	1	....	....	4	....	....	10	45	....	10	....	....	15
	"	50	25	.15	....	10	....	....	....	....	....	....	....	10	35	5	....	....	....	40
	"	46	20	.35	....	15	....	....	....	....	....	....	....	....	25	....	25	....	....	35
Turkey Foot Lake	7/24/26	46	38	.65	....	....	5	....	....	....	....	....	....	....	95	....	....	....	....	....
	"	45	31	.30	....	47	....	....	....	1	....	....	....	....	....	....	5	....	....	47
	"	40	26	.75	....	....	2	1	....	....	....	35	....	....	55	....	2	....	....	5
	"	44	29	.65	....	....	2	1	....	....	20	10	....	....	31	....	....	....	30	6
N*	7/6/26	49	11	.25	20	....	....	....	....	....	10	....	20	....	10	....	....	20	....	20

*Nesmith Lake.

TABLE II.

Notemigonus crysoleucas.

Percentage Composition of Alimentary Canal Contents.

Locality	Date	Length of Fish, mm.	Length of Intestine, mm.	Degree Filled	Inorganic	Plant Debris	Blue-green algae	Diatoms	Desmids	Filamentous Green algae	Statoblasts of Bryozoa	Copepoda	Cladocera	Ostracoda	Chironomid Larvae	Other Insects	Animal Debris
East R.	7/3/26	42	37	.50	3	....	5	....	....	....	....	....	....	90	....	....	2
	"	42	31	.25	1	90	....	....	....	3	....	5	....	....	....	....	1
	"	44	48	.25	2	....	2	....	....	4	....	....	....	87	....	....	5
	"	40	33	.66	5	5	1	....	....	1	....	....	....	86	....	....	2
New Reservoir	7/15/29	29	21	.75	....	....	3	....	....	2	....	....	90	5	....	....	....
	"	30	23	.50	1	....	....	....	....	....	....	....	32	35	....	30	2
	"	32	23	.66	5	....	....	....	....	....	....	....	90	....	....	....	5
	"	32	25	.75	....	....	....	1	....	1	....	....	90	....	....	8	....
	"	33	24	.75	....	....	....	....	....	1	....	4	30	15	....	50	....
	"	33	25	.50	....	2	....	1	....	....	....	....	70	....	....	27	....
	"	33	29	.50	....	....	....	....	....	2	5	....	85	2	....	1	5
	"	33	27	.75	....	....	....	1	....	1	....	....	75	18	....	....	5
	"	34	24	.33	....	....	....	2	....	1	....	....	90	7	....	....	....
	"	34	25	.50	3	....	....	1	....	....	....	....	90	....	....	3	3
	"	35	30	.66	....	1	....	....	....	....	....	....	95	3	....	....	1
New Reservoir	7/22/26	34	30	.66	5	3	....	....	....	2	....	....	75	10	....	....	5
	"	35	31	.25	35	....	....	....	....	40	....	....	20	....	....	....	5
	"	37	35	.50	....	....	....	....	....	1	....	....	55	43	....	....	1
	"	37	30	.50	2	1	....	....	....	1	....	5	....	90	....	....	1
	"	37	31	.75	2	1	....	....	....	1	....	....	95	....	....	....	1
	"	37	33	.75	1	....	....	....	....	1	....	12	85	....	....	....	1
	"	38	35	.50	1	....	1	....	....	5	....	....	5	65	15	5	3
	"	38	32	.33	15	10	....	....	....	5	....	....	55	....	....	....	15
	"	38	37	.81	....	....	....	....	....	1	....	....	49	49	1	....	....
	"	38	32	.50	1	....	....	....	....	1	....	....	95	3	....	....	....
	"	38	32	.66	1	1	....	....	....	....	....	15	70	13	....	....	....
	"	39	36	.66	1	1	....	....	....	1	....	10	1	80	....	5	1
	"	39	33	.50	1	....	....	....	....	1	....	....	49	49	....	....	....
	"	39	32	.50	55	10	....	....	....	10	....	....	....	5	....	....	20
	"	40	34	.25	50	....	....	....	....	....	....	....	5	....	....	....	45
	"	40	34	.50	2	1	....	....	....	....	....	....	48	48	....	....	1
	"	40	36	.75	1	....	....	....	....	1	....	50	24	24	....	....	....
	"	41	33	.25	60	....	....	....	....	5	....	....	....	20	....	....	15
	"	41	38	.50	1	....	....	....	....	....	....	80	....	18	....	....	1
	"	44	25	.75	8	....	....	....	....	1	....	....	....	90	....	....	1
	"	49	23	0	....	....	....	....	....	....	....	....	....	....	....	....	....
	7/24	40	37	.33	7	1	....	....	....	....	....	....	90	....	....	....	2
	7/29	41	35	.50	2	1	....	....	....	....	....	....	96	....	....	....	1
Turkey Foot	7/24	32	26	.25	20	20	....	....	....	....	....	....	....	....	....	....	50
	8/7	38	29	.50	1	1	....	....	....	....	....	80	18	....	....	....	....
Franklin County	?	53	60	.50	....	....	20	3	....	2	....	....	25	....	....	....	50
	?	63	80	.80	5	....	....	....	....	....	....	10	....	....	....	60	25
	?	77	85	.50	5	....	....	....	....	5	....	....	....	....	....	20	70
	?	63	65	.15	....	....	....	10	40	45	....	....	....	....	....	....	5
	?	118	160	.80	10	....	....	3	60	....	....	....	....	....	....	....	27

TABLE III.

Fundulus diaphanus menona.

Percentage Composition of Alimentary Canal Contents.

Locality	Date	Fish Length, mm.	Intestine Length, mm.	Degree Filled	Inorganic	Blue-green algae	One-celled Green algae	Filamentous Green algae	Higher Plant Debris	Protozoa	Copepoda	Cladocera	Ostracoda	Amphipoda	Chironomid Larvae	Gastropoda	Fish Eggs	Unrecognizable Organic
Turkey Foot Lake (All caught 1928)	7/10	46	30	1.00	10	....	....	8	3	5	5	10	25	....	5	....	....	29
	"	60	35	.75	5	....	....	15	5	3	....	7	20	2	20	3	....	20
	"	49	32	.15	2	....	40	....	....	....	5	15	....	5	8	....	....	25
	"	47	30	.50	10	....	....	....	5	....	25	30	....	....	....	....	....	30
	"	43	26	1.00	2	2	....	....	10	....	....	30	5	40	3	....	....	8
	"	34	17	.50	....	....	5	....	....	....	15	10	5	15	40	....	....	10
	"	46	24	.50	....	....	2	3	....	....	60	5	3	15	2	....	....	10
	"	37	22	.50	....	....	....	....	10	....	5	....	5	70	....	....	....	10
	"	34	17	.25	2	....	5	....	....	....	....	....	20	70	....	....	....	3
	"	45	24	.50	10	....	....	....	10	....	....	....	10	65	....	3	....	2
	"	48	24	.25	5	....	5	....	10	3	....	....	30	20	15	....	....	5
	"	50	28	.50	5	3	2	10	....	5	....	5	10	25	20	5	....	10
	"	37	20	.25	5	....	15	....	....	....	10	....	....	35	15	....	....	20
	"	48	25	1.00	3	....	....	10	....	....	30	....	....	40	5	....	....	12
	"	50	27	1.00	....	....	10	....	2	....	25	....	5	45	5	....	....	8
	"	47	30	1.00	....	....	3	10	....	....	....	5	2	60	10	....	....	10
	"	40	25	.25	....	5	10	....	15	....	....	10	50	....	....	....	....	10
	"	50	32	.75	3	....	5	5	3	....	....	5	10	....	15	....	35	19
	"	40	22	.50	....	....	10	....	....	5	25	50	....	....	....	....	....	10
	"	43	23	.50	....	....	7	....	....	3	30	55	....	....	....	....	....	5
	"	60	42	.25	....	....	....	10	....	5	....	5	25	30	5	....	....	20
	"	45	28	.50	....	....	....	5	....	....	7	....	10	45	15	....	....	13
	"	42	24	.75	....	....	2	3	....	....	5	....	5	20	60	2	....	3
	"	50	33	1.00	....	....	....	10	....	....	10	....	10	5	30	....	....	35
	"	53	34	0	....	....	....	....	....	....	....	....	....	....	....	....	....	....
	"	45	26	.25	....	....	....	....	....	4	70	10	....	....	3	....	....	13
	"	57	32	.50	8	....	....	....	....	....	10	15	20	12	....	....	....	35
	"	54	28	.25	....	5	....	....	....	....	5	10	15	30	15	....	....	20
	"	50	25	.25	3	....	3	....	2	....	....	7	....	50	10	....	....	25
	"	52	30	.75	....	....	....	....	5	....	....	10	8	45	10	....	....	22
	"	51	30	1.00	3	....	5	20	7	5	....	15	10	15	10	....	....	10
	"	52	28	1.00	....	....	5	5	7	....	....	....	2	3	3	....	....	75
	"	39	15	.25	....	....	3	5	....	....	....	25	25	5	2	....	....	30
	"	53	30	1.00	....	....	3	2	7	....	3	....	5	60	....	....	....	20
	"	50	27	.75	....	....	....	5	....	....	....	10	5	25	....	....	....	55
	"	45	23	.50	....	....	....	....	....	....	....	15	15	15	40	....	....	15
	"	42	20	.15	....	....	....	....	....	....	....	10	10	....	....	....	....	80
	7/24	60	35	.75	5	....	....	5	15	....	5	2	3	....	....	15	....	50
	"	62	35	1.00	....	....	3	2	....	....	5	20	5	55	5	....	....	10
	"	55	30	.25	....	....	....	....	3	....	....	20	40	....	40	....	....	32

AN ANALYSIS OF PLANATIONAL TERMS—AN ADDITION.*

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A paper under a somewhat different title† published in 1928 has aroused comments chiefly of two types: the one questions etymology and the other desires exact definitions of the terms considered in the original report.

An introductory word on terms in general may not be amiss. A non-progressive science has little need for new terms. But in an advancing science new phenomena will come under notice; new ideas will be born; new relations will become evident; and facts already known will gradually break up into parts easily differentiated once they are recognized. An idea cannot become useful public property until it is christened; it cannot be handled, inspected, tested, talked about, circumscribed, and related until a name brings to focus the light of individuality and separate entity. However, the term of the highest value is the one that makes possible the recognition of a new phenomenon or conception for the first time, and fosters its detailed study. If a name thus calls attention to a process which would otherwise go unnoticed it has served a very useful purpose indeed.

The caution employed in regard to the introduction of a new term should be equaled only by the care exercised in its subsequent use. A few of the tests to which a term should be subjected are as follows: first, it must be a step forward in an advancing science; second, progress has discovered an idea and its corresponding phenomenon and a new term is necessary to facilitate recognition and development; and third, the term proposed should so delineate, clarify, and etch into relief the idea or fact that both will be instantly recognized in all their relationships. Utility and expressiveness should be the critical tests. The striking connotation and the clear-cut emphasis surrounding a well-chosen term may be illustrated aptly by the

* Presented at the annual meeting of the Ohio Academy of Science, April 19, 1930.

† An analysis of erosional terms: Amer. Jour. Sci., XV, 471–483.

words "island universe" in astronomy, "barchane" in physiography, "dinosaur" in paleontology, and "electron" in physics, to mention only a few. The entrance of the word "barchane" into a discussion, for instance, arouses a definite mental picture definitive, descriptive, and causative—the term is particularly rich in suggestion. How great the difference between barchane and dune!* Names symbolical of a rich and precise nomenclature not only should aid the advancement of science but should also placard the steps of progress as they appear before us.

Let it be stated that the proposals were made not with the idea of creating an omnibus of terms to plague elementary students but with the purpose of emphasizing and perhaps predicting the trend and ramifications of physiography in relation to other phases of geology. The terms were proposed more particularly for the purpose of making it possible to direct attention upon certain processes from the standpoint either of physiography or of sedimentation, to isolate each process under a separate name so that its own peculiar characteristics stand out with utmost distinctness, and to promote an intensive analysis of the nature and method of that process.

It may be argued that a single word is sufficient to cover a number of roughly similar processes, e.g., corrasion for the destructive activities of streams, glaciers, and the wind. Yet who would wish to discard the word "plucking," a term of great utility and vividness of expression. After the same fashion abrasion by glaciers contrasts sharply with corrasion by streams in nature, method, and results. A further remark on the significance inherent in the type of term suggested will suffice, perhaps, to illustrate geologic utility. Does mariposition, for example, merit our attention? Why not use marine deposition? Strictly speaking, marine deposition means deposited in or by the sea—a rather loose definition on the whole. Mari position, on the contrary, signifies sea deposited, the agent being specifically designated. Sediments completely reworked by the sea and then subjected to mariposition receive the impress of a pure marine environment whereas those placed in the sea and scarcely touched by it receive much slighter indications of true marine surroundings. In the first case the sea is the

* W. M. Davis tells us that the Arabs have different names for dunes of different shapes. Essays, page 54.

active agent while in the second it is the passive receiver, surely a fact of significance to sedimentation.

The definitions below are appended in answer to the second comment mentioned in the initial paragraph. The scheme of terms refers exclusively to the physiographic processes and not to the surface forms. The usage of "erosion," it may be added, excludes "weathering" and restricts the word to a subject inherently active and mobile. Erosion comprehends motion; it represents part of the strikingly dynamic interlude, involving space translation, between original and derived physiographic forms.

I. PLANATION. Planation refers to the geologic activities of all the physiographic processes at work on the surface of the lithosphere tending to bring that surface to a common level.

II. EROSION. Erosion includes the acquisition of load by the physiographic agents of transportation, the actual transportation of the material, and the destruction of topographic forms and comminution of rock materials because of such transportation.

III. EOLATION. (Latin *Aeolus*, god of the winds; *-ationem*, or French *-ation*, that which is made or done by. Hence, "that which is done by the wind".) Eolation includes all the direct geologic activities of the wind, both destructive and constructive.

A. EOLIROSION. (From "eolian erosion." Latin *Aeolus; e* and *rodere*, to gnaw away. Hence, "wind gnawed" or "eaten away by wind".) Eolirosion includes the pick-up and transportation of materials by the wind and the geologically destructive effects accomplished because of such transportation.

1. *Eoliportation.* (Latin *Aeolus; portare*, to carry; *-ation*, the act of. Hence, "the act of wind carrying," or "carried by the wind".) Eoliportation refers to the transfer of (chiefly) rock materials on the earth's surface by the agency of the wind.

2. *Blastation.* (AS. *blaest*, a puff of wind, a blowing, plus *-ation*, the act of. Hence, "the act of blowing or rending rock".) Blastation includes the geologically destructive processes in which sand and dust particles strike rock faces or grind upon each other.

B. EOLIPOSITION. (Latin *Aeolus; ponere, positum*, to place. Hence, "wind placed".) Eoliposition refers to the

deposition of materials which have been transported by the wind; it is the process which occurs when transportation ceases or becomes ineffective.

IV. GLACIATION. (Latin *glacies*, ice, plus *-ation*. Hence, "that which is done by ice".) Glaciation includes all the geologic activities of glaciers, both destructive and constructive.

A. GLACIROSION. Glacirosion includes the pick-up and transportation of materials, produced or supplied, and the geologically destructive activities of glaciers.

1. *Glaciportation*. Glaciportation refers to the transfer of materials by the agency of glaciers.
2. *Abrasion* refers to the process by which a glacier scours and wears away a rock surface, or the fragments undergoing transportation.
3. *Plucking* refers to the process whereby a glacier lifts or tears away rock fragments or projections to which the ice has become attached.

B. GLACIPOSITION. Glaciposition refers to the deposition or rock materials which have been transported by glaciers.

V. FLUVIATION. (Latin *fluvius*, river, plus *-ation*. Hence, "that which is done by rivers".) Fluviation includes all the geologic activities of streams, both destructive and constructive.

A. FLUVIROSION. Fluvirosion designates the geologic work of pick-up, transportation, and destruction carried on by streams.

1. *Fluviportation* refers to the transfer of materials by the agency of streams.
2. *Corrasion* refers to the process whereby the channel of a stream is worn away chiefly by the impact of rock materials which themselves suffer wear during the procedure.
3. *Corrosion* is the process whereby a stream by its own solvent action, but predominantly by the help of solutes undergoing transportation, dissolves or chemically alters materials along its course of flow.

B. FLUVIPOSITION. Fluviposition refers to the deposition of rock materials which have been transported by streams.

VI. PLUVIATION. (Latin *pluvia*, rain, plus *-ation*. Hence, "that which is done by rain".) Pluviation includes all the geologic activities of rain and rainwash, both destructive and constructive.

A. PLUVIROSION. Pluvirosion refers to the geologic work of pick-up, transportation, and destruction carried on by rain and rainwash.

1. *Pluviportation* refers to the transfer of materials by the agency of rain.

B. PLUVIPOSITION. Pluviposition refers to the deposition of rock materials which have been transported by rain or rainwash.

VII. MARIATION. (Latin *mare*, sea, plus *-ation*. Hence, "that which is done by the sea".) Mariation includes all the direct geologic activities of the sea, both destructive and constructive.

A. MARIROSION. Mariosion refers to the geologic work of pick-up, transportation, and destruction carried on by the sea.

1. *Mariportation* refers to the transfer of materials by the agency of the sea.

B. MARIPOSITION. Mariposition refers to the deposition of rock materials which have been transported by the sea, chiefly waves, currents, and tides.

VIII. COLLUVIATION. (Latin *colluvies*, a mixture;* plus *-ation*. Hence, "that which is done by a mixture" or, better, "by mixing".) Colluviation includes all the geologic activities of gravity, both destructive and constructive.

A. COLLUVIROSION. Colluvirosion includes the movement of rock materials under the influence of gravity and the destructive effects accomplished.

1. *Colluviportation* refers to the movement of (chiefly) rock material under the influence of gravity.

B. COLLUVIPOSITION. Colluviposition refers to the deposition, by coming to rest, of rock materials which have undergone colluviportation.

IX. TERRAQUIATION. (Latin *terra*, earth; *aqua*, water; plus *-ation*. Hence, "that which is done by earth water".) Terraquiation includes all the geologic activities performed by ground water, both destructive and constructive.

A. TERRAQUIROSION. Terraquirosion refers to the pick-up and transportation of materials and the geologically destructive activities performed by ground water.

1. *Terraquiportation* refers to the transfer of materials by the agency of ground water.

B. TERRAQUIPOSITION. Terraquiposition refers to the deposition, or precipitation, of materials which have been transferred by ground water.

*See G. P. Merrill: Rocks, Rock-Weathering and Soils, 1913, 307–8.

PLANATION.

DENUDATION		SEDIMENTATION	
Weathering	*Erosion*	*Deposition*	
	Eolirosion Eoliportation Blastation	Eoliposition	=Eolation
"	Glacirosion Glaciportation Abrasion Plucking	Glaciposition	=Glaciation
"	Fluvirosion Fluviportation Corrasion Corrosion	Fluviposition	=Fluviation
"	Pluvirosion Pluviportation Corrasion (?)	Pluviposition	=Pluviation
"	Marirosion Mariportation Corrasion (?)	Mariposition	=Mariation
"	Colluvirosion Colluviportation Corrasion (?)	Colluviposition	=Colluviation
"	Terraquirosion Terraquiportation Solution (or corrosion) Corrasion	Terraquiposition	=Terraquiation

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